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(54) **Method and apparatus for opening, closing and rotating rigid marine sails.**

(57) A rigid marine sail comprises sail portions (6B) pivotably movable between an open and a closed position about an axis forward of a rotatable mast (1). Signals representative of the wind velocity at predetermined time intervals and signals representative of the wind direction at said intervals are each smoothed (16) and, on the basis of the smoothed signals, a determination is made whether the sail portions are to be open or closed, and the sail is operated accordingly (11,17,18,19). An optimum sail angle is determined for maximum propulsive effect when open and minimum said wind resistance when closed, and the mast and sail is rotated (5,20,21,22) as a whole in accordance with the optimum angle. This permits automatic and effective utilization of the wind force when of a suitable velocity in a suitable direction.

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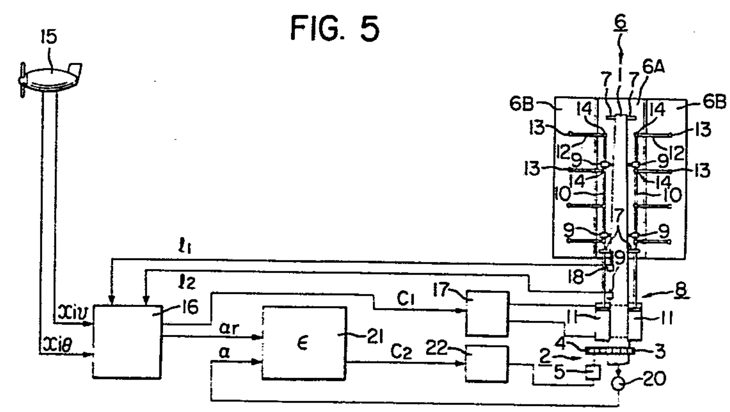
FIG. 5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METHOD AND APPARATUS FOR OPENING, CLOSING AND ROTATING RIGID MARINE SAILS

The present invention relates to a method and apparatus for opening, closing and rotating a rigid marine sail carried by a ship with a view to effectively utilizing the wind force for propulsion of the ship.

The fitting of sails to ships is currently being proposed with the object of saving energy. One type of sail which may be fitted to ships is a canvas sail employed conventionally. A sail of this kind however requires much time and labour for handling.

To solve this difficulty, a generally rigid marine sail comprising thin metal sheets or synthetic resin sheets fitted to reinforcing ribbed members has been invented in place of the above-mentioned canvas sail. These rigid sails are adapted to be opened and closed by mechanical means and can thus solve the above-mentioned problem.

One of such rigid sails is substantially as shown in Figs. 1 to 4 hereof and has been previously proposed in Japanese Patent Provisional Publication No. 47,994/80. In Figs. 1 to 4, a mast 1 is mounted substantially vertically on the deck (not shown) of a ship. A mast rotating mechanism 2 is operable to rotate the mast 1 around the axis thereof. This mechanism 2 comprises a gear 3 fixed on the periphery of the mast 1 at the lower portion thereof and a motor 5 having another gear 4 engaging with the above-mentioned gear 3. A rigid sail 6 is fitted to the mast 1 parallel with the axis thereof by means of a plurality of fitting members 7. The rigid sail 6 comprises a central sail portion 6A fixed to the mast 1, and two sail portions 6B fitted to the respective side edges of the central sail portion 6A so as to be pivotably movable. An opening/closing device 8 is provided for opening and closing each of the sail portions 6B, this device 8 comprising: a movable rod 10 vertically movably fitted, by means of a plurality of guide members 9, to the mast 1 in parallel therewith; a ram 11 comprising, for example, a piston for vertically moving the movable rod 10, and a plurality of connecting rods 12 provided at prescribed intervals in a vertical column on each of the sail portions 6B, one end of each connecting rod 12 being connected, through a respective universal bearing 13, to each of the sail portions 6B at prescribed intervals to form a vertical column, and the other end of each connecting rod 12 being connected, through another respective universal bearing 14, to the movable rod 10 at prescribed intervals to form a vertical column.

By driving the motor 5 of the mast rotating mechanism 2, the rigid sail 6 is rotated together with the mast 1 by means of the gears 3 and 4. The sail portions 6B of the rigid sail 6 are opened, as shown in Figs. 1 and 2, by raising the movable rods 10 with the ram 11, and are closed, as shown in Figs. 3 and 4, by lowering the movable rods 10 with the ram 11.

One problem that is now appreciated with the above described rigid sails is that the wind velocity and the wind direction at sea are in practice continually changing.

An object of the present invention is to provide a method and apparatus which permits easy and reliable rotation, opening and closing of a rigid marine sail on a ship with a view to effectively utilizing the wind force for propulsion of the ship.

According to the present invention there is provided a method of opening, closing and rotating a generally rigid marine sail which comprises at least first and second sail portions pivotably movable between an open and a closed position about a substantially vertical axis associated with a mast of a ship, said mast being rotatable about its own axis,

characterized by:

smoothing a plurality of signals representative of the wind velocity at predetermined time intervals;

smoothing a plurality of signals representative of the wind direction at predetermined time intervals;

determining on the basis of smoothed wind velocity signal and said smoothed wind direction signal whether said sail portions are to be in the open or closed position;

automatically operating an apparatus for opening and closing said sail portions in accordance with said determination;

determining an optimum sail angle, relative to the ship, at which said sail portions provide maximum propulsive effect when in said open position and minimum wind resistance when in said closed position; and

rotating said mast together with said sail portions in accordance with any deviation between the actual sail angle and said optimum sail angle whereby to tend always to maintain said sail portions at said optimum angle.

The invention also provides apparatus for opening, closing and rotating a generally rigid marine sail which comprises at least first and second sail portions pivotably movable between an open and a closed position about a substantially vertical axis associated with a mast of a ship, and said mast being rotatable about its own axis,

characterized by:

meter means (15) on said ship for providing signals representative of the wind velocity and signals representative of the wind direction;

means (16) for smoothing a plurality of the signals representative of the wind velocity at predetermined time intervals;

means (16) for smoothing a plurality of the signals representative of the wind direction at predetermined time intervals;

means (16) for determining on the basis of said smoothed wind velocity signal and said smoothed wind direction signal whether said sail portions are to be in the open or closed position;

apparatus (11,17,18,19) automatically operable to open and close said sail portions in accordance with said determination;

means (16) for determining an optimum sail angle, relative to the ship, at which said sail portions provide maximum propulsive effect when in said open position and minimum wind resistance when in said closed position; and

apparatus (5,20,21,22) for rotating said mast together with said sail portions in accordance with any deviation between the actual sail angle and said optimum sail angle whereby to tend always to maintain said sail portions at said optimum angle.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Fig. 1 is a plan view illustrating an open state of a previously proposed rigid sail;

Fig. 2 is a partially cutaway front view illustrating the open state of the sail of Fig. 1;

Fig. 3 is a plan view illustrating a closed state of the sail of Fig. 1;

Fig. 4 is a partially cutaway front view illustrating the closed state of the sail of Fig. 1;

Fig. 5 is a schematic descriptive view illustrating an embodiment of the present invention;

Fig. 6 is a flow chart illustrating a method of smoothing the wind direction signals in a method according to the invention;

Fig. 7 is a descriptive drawing of wind direction sensing;

Fig. 8 is a descriptive drawing of the true wind velocity $\mathcal{V}_a$, the relative wind velocity $\mathcal{V}$, and the relative wind direction θ, in the case where the ship speed is $\mathcal{V}_s$;

Fig. 9 is a descriptive drawing illustrating conditions allowing safe and effective utilization of the wind force for propulsion of the ship;

Fig. 10 is a graph showing the relationship between the relative wind direction and the set value of sail angle; and

Figs. 11A, 11B and 11C are respective parts of a flow chart of an embodiment of the method of the present invention.

To comply with the above-mentioned object, we carried out extensive studies. As a result, we developed a method for rotating, opening and closing a rigid marine sail on a ship, which permits easy and reliable operation, opening and closing of the rigid sail, in response to the wind velocity and the wind direction which change with time on the sea, with a view to effectively utilizing the wind force for propulsion of the ship.

The application of a method of the present invention to the rigid sail shown in Figs. 1 to 4 is described below with reference to Figs. 5, 11A, 11B and 11C.

In Fig. 5, 15 is a wind velocity/wind direction meter attached to the ship (not shown). 16 is a calculating device which has the functions to smooth, at prescribed intervals, a plurality of wind velocity signals, and a plurality of wind direction signals from the wind velocity/wind direction meter 15 to determine whether or not thus smoothed wind velocity signals and wind direction signals satisfy conditions suitable for opening the two sail portions 6B, and send a sail portion opening/closing instruction signal C_1 to a lift controller described later in response to the results of the above determination. At the same time, the calculating device 16 has the function to calculate the optimum sail angle α_r in response to the smoothed wind direction signals, which angle (α_r) of the rigid sail 6 relative to the horizontal reference one of the ship provides the maximum propulsion to the rigid sail 6 when the sail portions 6B are opened and can minimize the wind resistance acting on the rigid sail 6 when the sail portions 6B are closed. The calculating device 16 has the function to send the calculated results to a mast rotating mechanism described later. 17 is a lift controller which is actuated by a sail portion opening/closing instruction signal C_1 sent from the calculating device 16, and has the function to drive the lifts 11 simultaneously. 18 and 19 are limit switches attached to the mast 1. The limit switch has the function to send a sail portion opening completion signal ℓ_1 to the calculating device 16 when the sail portions 6B are completely opened. The other limit switch 19 has the function to send a sail portion closing completion signal ℓ_2 to the calculating device 16 when the sail portions 6B are completely closed. 20 is an angle detector which is attached to the mast 1 for detecting the rotation angle of the mast 1. 21 is the mast rotation controller which has the functions to determine the deviation ε of the actual sail angle α, which angle α is detected by the angle detector 20 relative to the horizontal reference line of the ship, from the above-mentioned optimum sail angle α_r and send the mast rotation instruction signal C_2 to the mast rotating mechanism controller described later until the deviation ε becomes zero. 22 is a mast rotating mechanism controller which is actuated by the mast rotation instruction signal C_2 and drives the mast rotating mechanism 2.

A plurality of wind velocity signals and a plurality of wind direction signals from the wind velocity/wind direction meter 15 are smoothed by the calculating device 16 at prescribed time intervals. The reason for the smoothing is as follows: Since both the wind velocity signals and the wind direction signals contain variable components of a considerably high frequency, it is not proper to use these wind velocity signals and wind direction signals both containing such high-frequency variable components for rotating, opening and closing operations of the rigid sail. Smoothing is possible by any of the following two methods:

Smoothing method 1 :

Measuring wind velocity signals or wind direction signals from the wind velocity/wind direction meter at prescribed time intervals, and calculating these plurality of wind velocity signals or wind direction signals in accordance with the following equation (1):

$$\bar{\chi}_n = (\chi_1 + \chi_2 + \dots\dots + \chi_{n-1} + \chi_n)/n \quad \dots\dots \quad (1)$$

where, $\bar{\chi}_n$: Smoothed wind velocity signals or wind direction signals;

χ_n : n-th wind velocity signal or wind direction signal;

n : the number of wind velocity signals or wind direction signals.

Smoothing method 2 :

Measuring wind velocity signals or wind direction signals from the wind velocity/wind direction meter at prescribed time intervals, and calculating these plurality of wind velocity signals or wind direction signals in accordance with the following equation (2):

$$\bar{\chi}_n = \bar{\chi}_{n-1} + (\chi_n - \bar{\chi}_{n-1}) \exp(-\frac{\Delta t}{T}) \quad .... \quad (2)$$

where, $\bar{\chi}_n$: smoothed wind velocity signal or wind direction signal,

$\bar{\chi}_{n-1}$: smoothed wind velocity signal or wind direction signal directly before $\bar{\chi}_n$,

χ_n : n-th wind velocity signal or wind direction signal,

T : time constant under the first order lag, and

Δt : time interval for measuring the wind velocity or wind direction.

When smoothing wind velocity signals, calculation can be performed by the above-mentioned equations (1) and (2) with no problem, since the value of wind velocity signal continuously varies. When smoothing wind direction signals, however, if the wind direction changes continuously in one direction, i.e., if it changes by more than 360° clockwise or anticlockwise, the wind direction signals always contain a point of discontinuity. This is due to the fact that a wind direction signal χ_i is put out from the wind direction meter in the form of, for example, a voltage as shown in Fig. 7. More particularly, when the wind direction changes from just behind the ship clockwise by 360°, the wind direction signal χ_i varies from 0 V to 10 V. Therefore, a point of discontinuity occurs between 0 V and 10 V. To solve this problem, the above-mentioned wind direction signal χ_n is converted into a value X_n to which the equations (1) and (2) presented above are applied. The flow chart for the calculation of the value X_n is shown in Fig. 6. When the wind direction signal changes, for example, from 0.56 V (-160°) anticlockwise to 9.7 V (+170°), it is converted into the following continuity of values:

Wind direction signal before conversion:

$$\chi_{n-1} = 0.56 \text{ V } (-160°) \longrightarrow \chi_n = 9.7 \text{ V } (+170°)$$

Wind direction signal after conversion:

$$X_{n-1} \longrightarrow X_n = X_{n-1} - (0.56 + 10 - 9.7) \text{ V } (-30°)$$

As shown in Fig. 7, the range of possible values of the wind direction signal χ_i is from 0 V (-180°) to 10 V (+180°), whereas the wind direction signal X_n after conversion may take a value beyond the above-mentioned range. When the final wind direction signal $\overline{X}_n$ obtained after smoothing takes a value corresponding to -200°, therefore, this value is converted into another value corresponding to +160°.

The degree of the above-mentioned smoothing can be freely changed by selecting the number n of wind velocity signals or wind direction signals in the above-mentioned equation (1), and by selecting the time constant T in the above-mentioned equation (2).

Then, the calculating device 17 determines, on the basis of the smoothed wind velocity signals and wind direction signals thus obtained, whether or not the wind force can be safely and effectively utilized as the propulsion for the ship. The following three conditions are set for the above determination:

(1) $\mathcal{V} \leqq \mathcal{V}_u$

where, $\mathcal{V}$: apparent wind velocity measured on the ship (relative wind velocity); and

$\mathcal{V}_u$: upper limit value of the "$\mathcal{V}$" determined by the total area of the rigid sail and the stability of the ship;

(2) $\mathcal{V} \leqq \mathcal{V}_{au}$

where, $\mathcal{V}_a$: actual wind velocity on the sea (true wind velocity); and

$\mathcal{V}_{au}$: upper limit value of "$\mathcal{V}_a$" determined by the total area of the rigid sail and the stability of the ship; and

(3) $\theta \geqq \theta_\ell$

where, θ : apparent wind direction measured on the ship (relative wind direction); and

θ_ℓ : the lower limit value of the "θ", in which the rigid sail no longer produce an effective propulsion.

Fig. 8 shows the relationship between the ship speed $\mathcal{V}_s$, the relative wind velocity $\mathcal{V}$, the true wind velocity $\mathcal{V}_a$ and the relative wind direction θ.

The relationship between the above-mentioned $\mathcal{V}_s$, $\mathcal{V}$, $\mathcal{V}_a$ and θ is expressed by the following equation (3):

$$\mathcal{V}_a^2 = \mathcal{V}_s^2 + \mathcal{V}^2 - 2\,\mathcal{V}_s\,\mathcal{V}\cos\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

As for the above-mentioned conditions (1) and (3), determination can be easily made by comparing wind velocity signals with the prescribed upper limit value $\mathcal{V}_u$ and comparing wind direction signals with the prescribed lower limit value θ_ℓ. With regard to the condition (2), in which the true wind velocity that cannot be directly measured on a ship is involved, determination is made with the use of the above-mentioned equation (3). More specifically, determination is done using the following equation (4) solving the quation (3) as to the relative wind velocity v by introducing the upper limit value v_{au} as the true wind velocity v_a:

$$v \leqq v_s \cos \theta + \sqrt{-v_s^2 \sin^2\theta + v_{au}^2} \quad \ldots\ldots\ldots \text{(4)}$$

In the equation (4), when the ship speed v_s can be considered to be constant, it would be possible to make determination on the above-mentioned condition (2) with the use of two data, i.e., the relative wind direction θ and the relative wind velocity v. The value obtained by substituting the relative wind direction θ into the right side of the equation (4) and the actually measured relative wind velocity v are compared. If the former value is larger than the latter one, the above-mentioned condition (2) is satisfied. Fig. 9 shows an example of the range within which the wind force dependent on the above-mentioned three conditions can be safely and effectively utilized as the propulsion for the ship.

A sail portion opening/closing instruction signal C_1 is sent from the calculating device 16 to the lift controller 17, in response to the result of the above-mentioned determination. Namely, when the wind force is determined to be capable of being safely and effectively utilized as the propulsion for the ship, the calculating device 16 issues an opening instruction signal of the sail portions 6B to the lift controller 17. This causes actuation of the lifts 11 to raise the movable rods 10, thus opening the sail portions 6B. When the wind force is determined not to be capable of being safely and effectively utilized as the propulsion for the ship, on the other hand, the calculating device 16 issues a closing instruction signal of the sail portions 6B to the lift controller 17. This causes actuation of the lifts 11 to lower the movable rods 10, thus closing the sail portions 6B. When opening or closing of the sail portions 6B is completed, the limit switch 18 or 19 is actuated and a sail portion opening completion signal ℓ_1 or a sail portion closing completion signal ℓ_2 is transmitted to the calculating device 16 for confirmation of opening or closing of the sail portions 6B.

Then, the optimum sail angle is calculated by the calculating device 16 on the basis of the smoothed wind direction signals. This is done as follows. As shown in Fig. 10, the relationship between the relative wind direction and the sail angle giving the maximum propulsion in the opened position of the sail portions 6B, and the relationship between the relative wind direction and the sail angle giving the minimum wind resistance to the rigid sail in the closed position of the sail portions 6B are previously calculated and stored in the calculating device 16. In response to the relative wind direction signals from the wind velocity/wind direction meter 15, the device 16 calculates the sail angle giving the maximum propulsion when the sail portions 6B are opened, and on the other hand the sail angle giving the minimum wind resistance to the rigid sail 6 when the sail portions 6B are closed, these angles being set as the optimum sail angle α_r.

Then, the deviation ε of the actual sail angle α, which angle α is detected by the angle detector 20 relative to the horizontal reference line of the ship, from the set value of the optimum sail angle α_r is calculated by the mast rotation controller 21, and a mast rotation instruction signal C_2 is sent to the mast rotating mechanism controller 22 until the above deviation ε becomes zero. The mast rotating mechanism 2 is driven by the mast rotating mechanism controller 22, and the rigid sail 6 is rotated, together with the mast, to form the optimum sail angle.

According to the present invention, as described above, it is possible to easily and certainly rotate, open and close a rigid sail equipped on a ship in response to the wind velocity and the wind direction which change with time on the sea, with a view to effectively utilizing the wind force as the propulsion for the ship, thus providing industrially useful effects.

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CLAIMS:

1. A method of opening, closing and rotating a generally rigid marine sail which comprises at least first and second sail portions pivotably movable between an open and a closed position about a substantially vertical axis associated with a mast of a ship, and said mast being rotatable about its own axis,

characterized by:

smoothing a plurality of signals representative of the wind velocity at predetermined time intervals;

smoothing a plurality of signals representative of the wind direction at predetermined time intervals;

determining on the basis of smoothed wind velocity signal and said smoothed wind direction signal whether said sail portions are to be in the open or closed position;

automatically operating an apparatus for opening and closing said sail portions in accordance with said determination;

determining an optimum sail angle, relative to the ship, at which said sail portions provide maximum propulsive effect when in said open position and minimum wind resistance when in said closed position; and

rotating said mast together with said sail portions in accordance with any deviation between the actual sail angle and said optimum sail angle whereby to tend always to maintain said sail portions at said optimum angle.

2. A method as claimed in claim 1, characterized in that either or both of said plurality of wind velocity signals and said plurality of wind direction signals are smoothed in accordance with the following equation:

$$\bar{x}_n = (x_1 + x_2 + \ldots\ldots + x_{n-1} + x_n)/n$$

where $\bar{x}_n$: smoothed wind velocity signal or smoothed wind direction signal,

x_n : n-th wind velocity signal or wind direction signal, and

n : the number of wind velocity signals or wind direction signals.

3. A method as claimed in claim 1, characterized in that either or both of said plurality of wind velocity signals and said plurallity of wind direction signals are smoothed in accordance with the following equation:

$$\bar{x}_n = \bar{x}_{n-1} + (x_n - \bar{x}_{n-1}) \exp(-\frac{\Delta t}{T})$$

where $\bar{x}_n$: smoothed wind velocity signal or smoothed wind direction signal,

$\bar{x}_{n-1}$: smoothed wind velocity signal or smoothed wind direction signal directly before x_n,

x_n : n-th wind velocity signal or wind direction signal,

T : time constant under the first order lag, and

Δt : time interval for measuring the wind velocity or wind direction.

4. A method as claimed in any one of claims 1 to 3, characterized in that:

said sail portions are to be in said open position when the following conditions (1) to (3) are satisfied:

(1) $v \leqq v_u$

where v : apparent wind velocity measured on the ship, and

v_u : upper limit value of the "v" determined by the total area of the rigid sail and the stability of the ship;

(2) $v \leqq v_{au}$

where v_a : actual wind velocity relative to the sea, and

v_{au}: upper limit value of "v_a" determined by the total area of the rigid sail and the stability of the ship; and

(3) $\theta \geqq \theta_{\ell}$

where θ : apparent wind direction measured on the ship, and

θ_{ℓ} : lower limit value of the "θ", in which the rigid sail does not produce effective propulsion;

and said sail portions are closed when any one of the following conditions (4) to (6) are satisfied:

(4) $\mathcal{V} > \mathcal{V}_u$

(5) $\mathcal{V}_a > \mathcal{V}_{au}$, and

(6) $\theta < \theta_{\ell}$.

5. Apparatus for opening, closing and rotating a generally rigid marine sail which comprises at least first and second sail portions pivotably movable between an open and a closed position about a substantially vertical axis associated with a mast of a ship, and said mast being rotatable about its own axis,

characterized by:

meter means (15) on said ship for providing signals representative of the wind velocity and signals representative of the wind direction;

means (16) for smoothing a plurality of the signals representative of the wind velocity at predetermined time intervals;

means (16) for smoothing a plurality of the signals representative of the wind direction at predetermined time intervals;

means (16) for determining on the basis of said smoothed wind velocity signal and said smoothed wind direction signal whether said sail portions are to be in the open or closed position;

apparatus (11,17,18,19) automatically operable to open and close said sail portions in accordance with said determination;

means (16) for determining an optimum sail angle, relative to the ship, at which said sail portions provide maximum propulsive effect when in said open position and minimum wind resistance when in said closed position; and apparatus (5,20,21,22) for rotating said mast together with said sail portions in accordance with any deviation between the actual sail angle and said optimum sail angle whereby to tend always to maintain said sail portions at said optimum angle.

FIG. 1

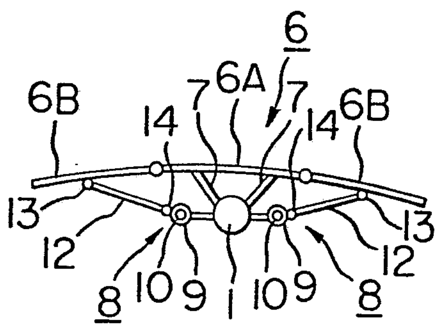
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FIG. 2

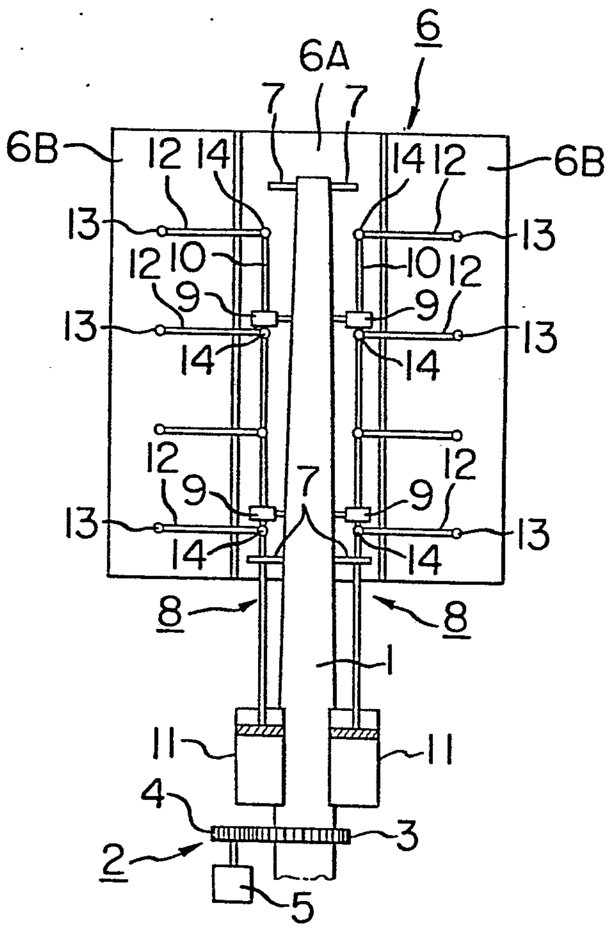
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FIG. 3

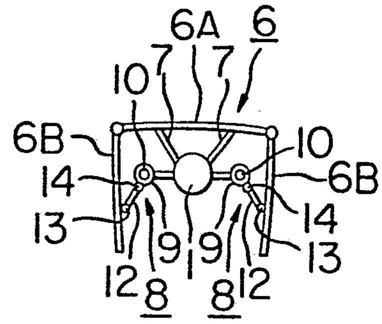
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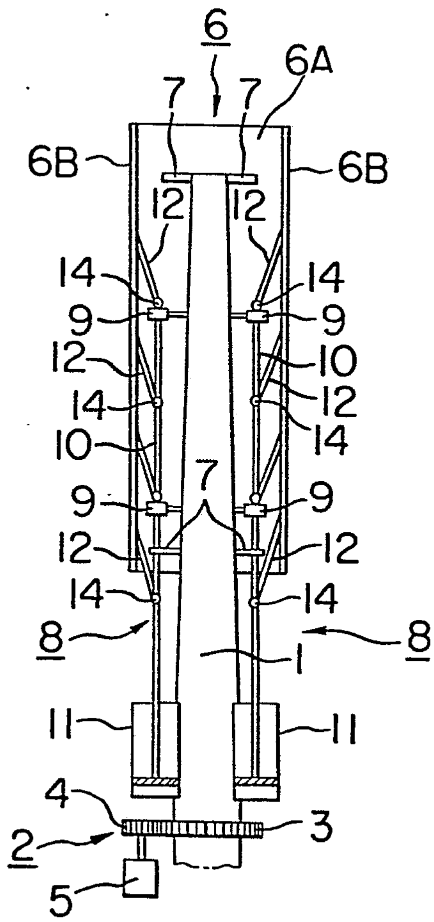
FIG. 4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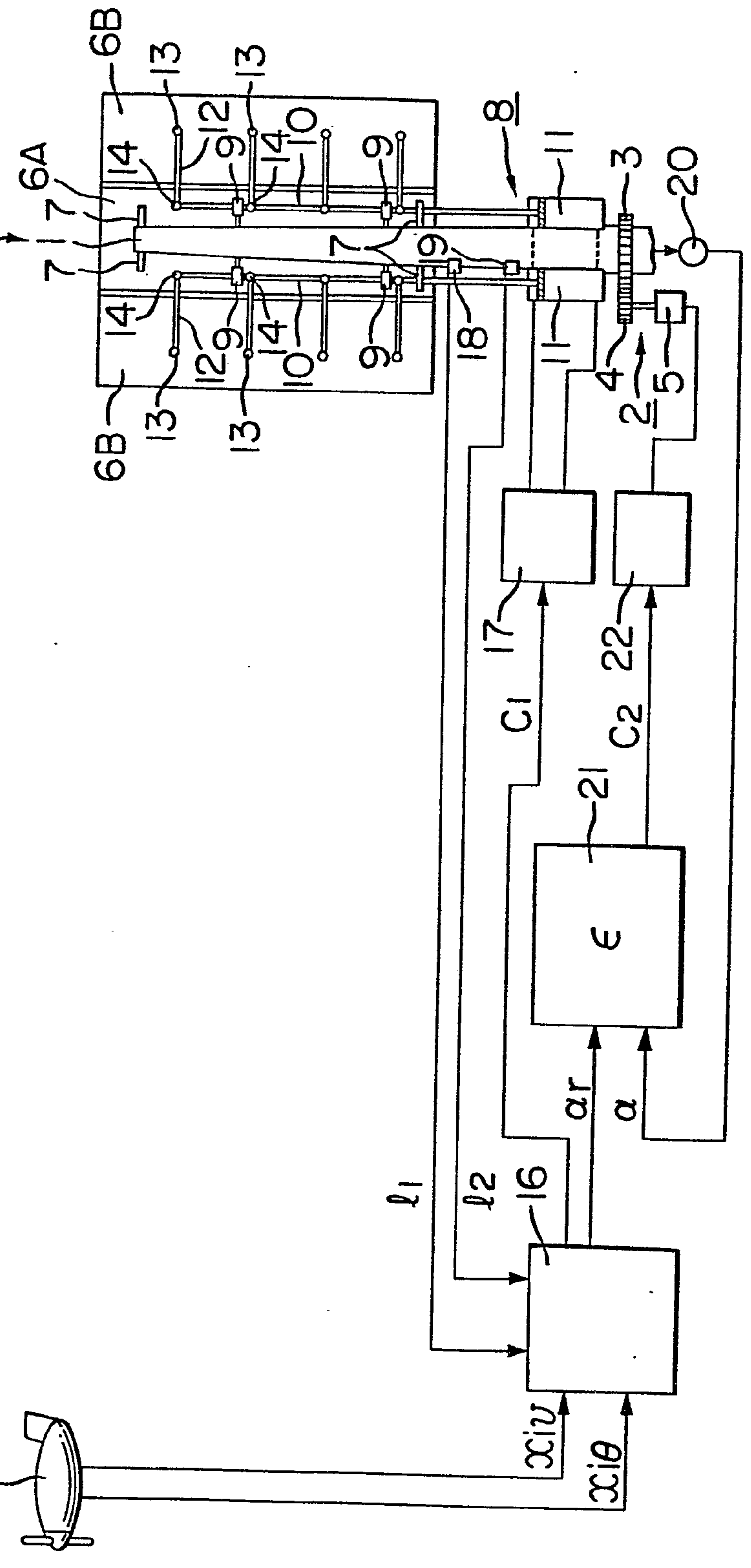

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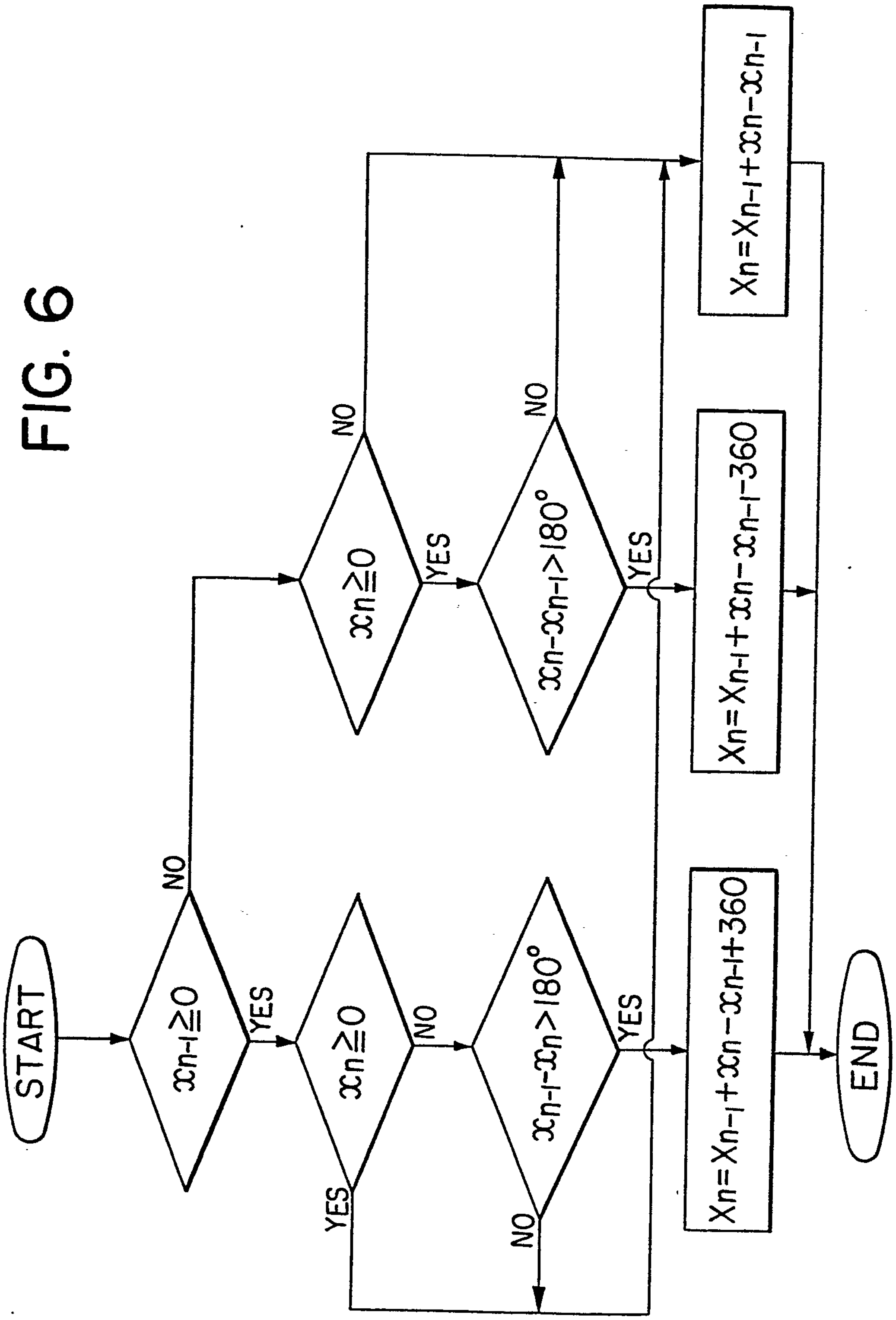
FIG. 5

FIG. 6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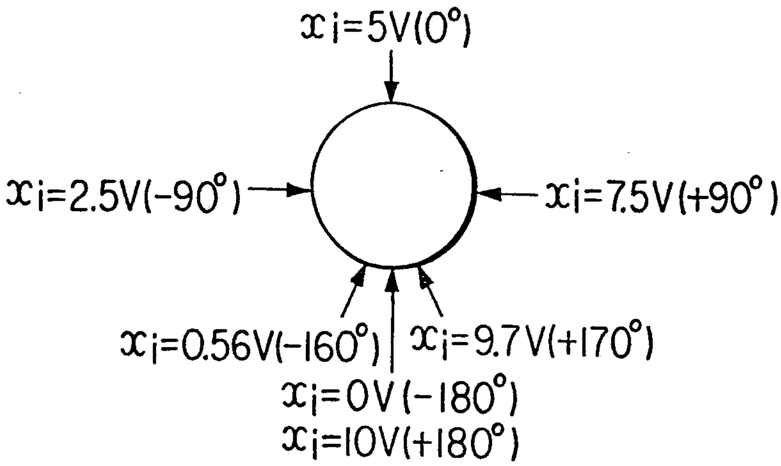
END

FIG. 7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x_i=7.5V(+90°)
x_i=0.56V(-160°)
x_i=9.7V(+170°)
x_i=0V(-180°)
x_i=10V(+180°)

FIG. 8

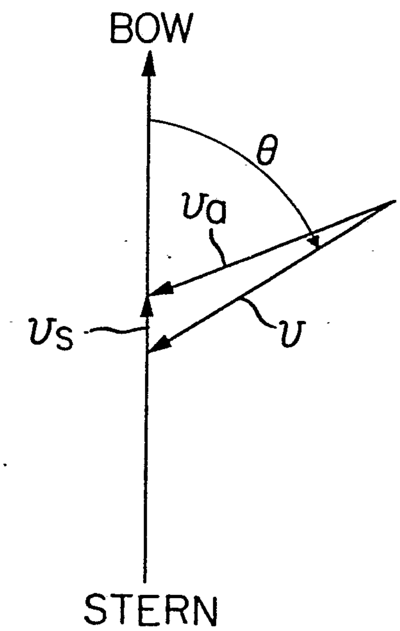
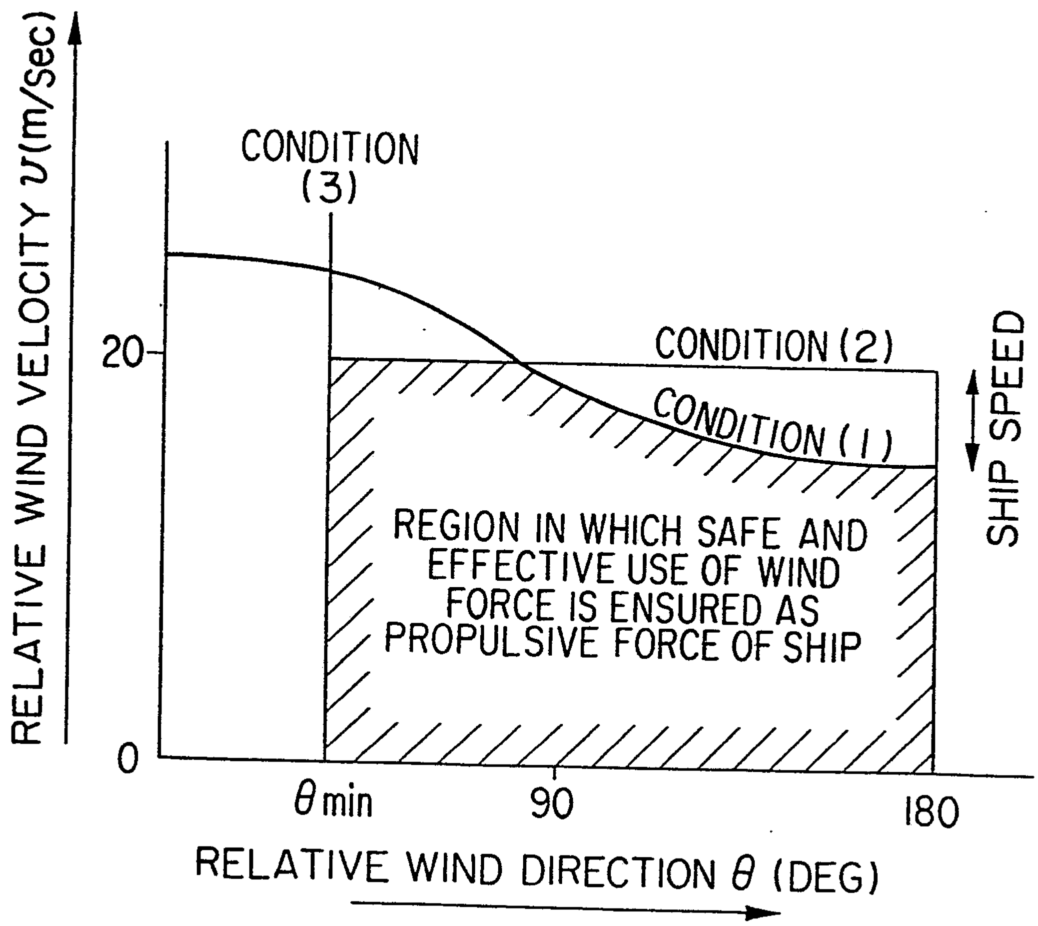

BOW
θ
v_a
v_s
v
STERN

FIG. 9



RELATIVE WIND VELOCITY v (m/Sec)
20
0
CONDITION (3)
CONDITION (2)
CONDITION (1)
SHIP SPEED
REGION IN WHICH SAFE AND EFFECTIVE USE OF WIND FORCE IS ENSURED AS PROPULSIVE FORCE OF SHIP
θ min
90
180
RELATIVE WIND DIRECTION θ (DEG)

FIG. 10

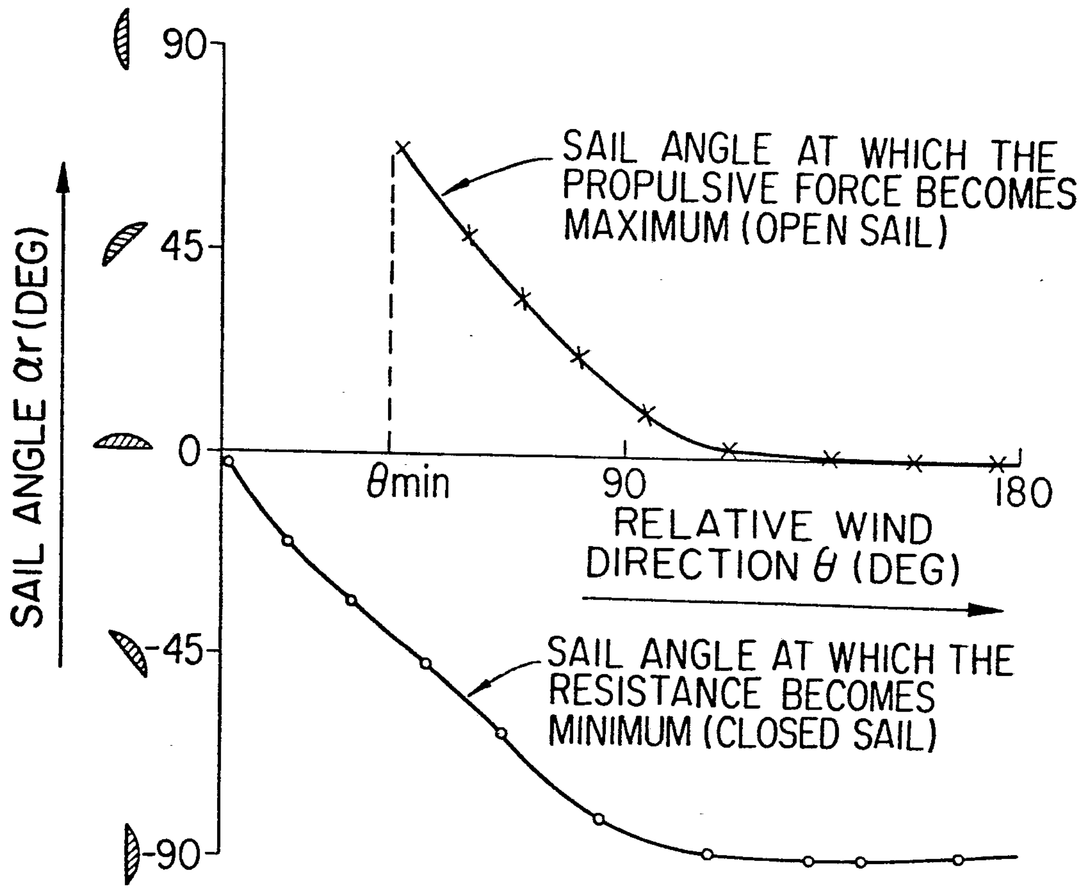

90
45
0
-45
-90
SAIL ANGLE αr (DEG)
θmin
90
180
RELATIVE WIND DIRECTION θ (DEG)
SAIL ANGLE AT WHICH THE PROPULSIVE FORCE BECOMES MAXIMUM (OPEN SAIL)
SAIL ANGLE AT WHICH THE RESISTANCE BECOMES MINIMUM (CLOSED SAIL)

FIG. 11A

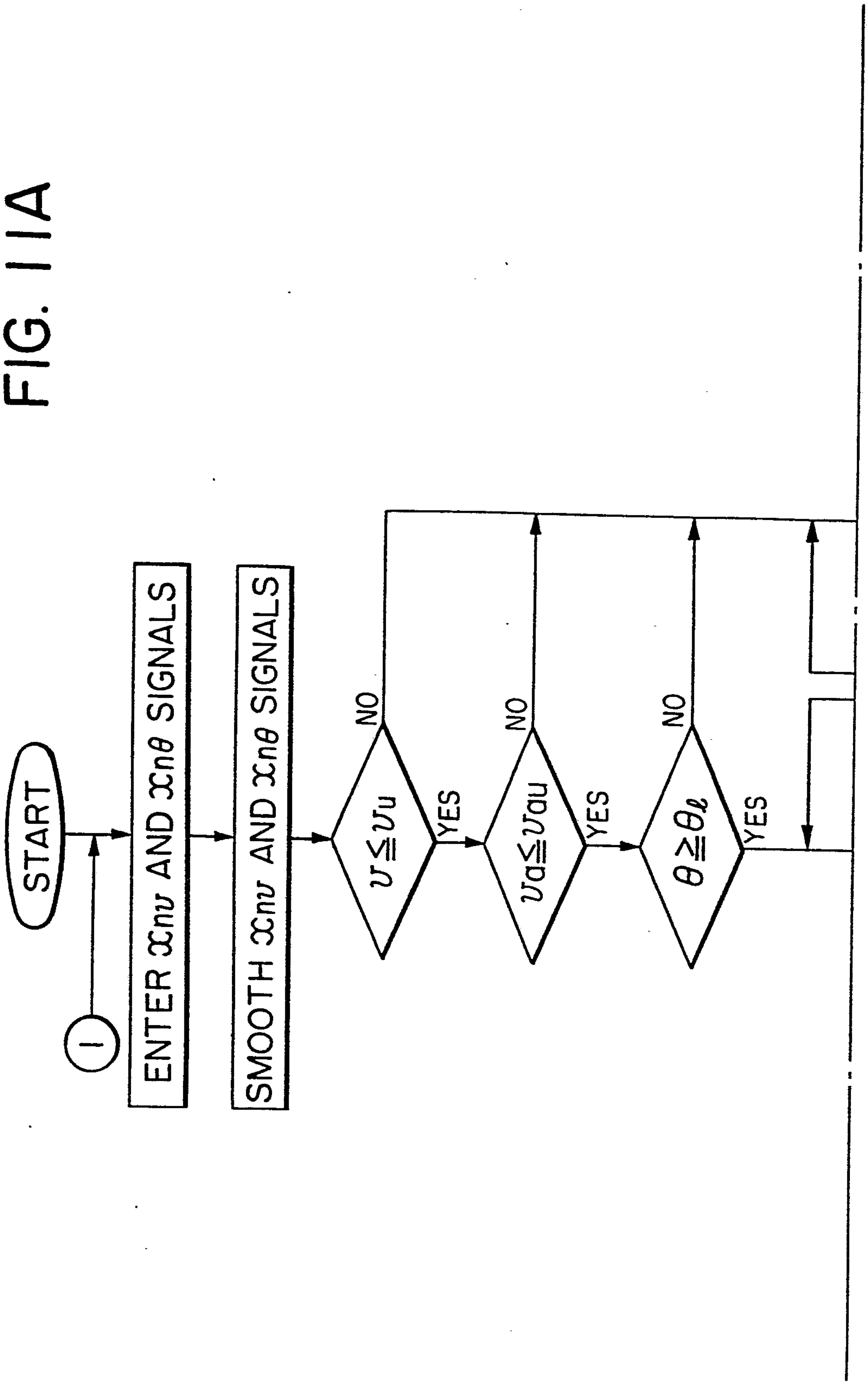

START
1
ENTER x_{nv} AND $x_{n\theta}$ SIGNALS
SMOOTH x_{nv} AND $x_{n\theta}$ SIGNALS
$v \leqq v_u$
NO
YES
$v_a \leqq v_{au}$
NO
YES
$\theta \geqq \theta_\ell$
NO
YES

FIG. 11B

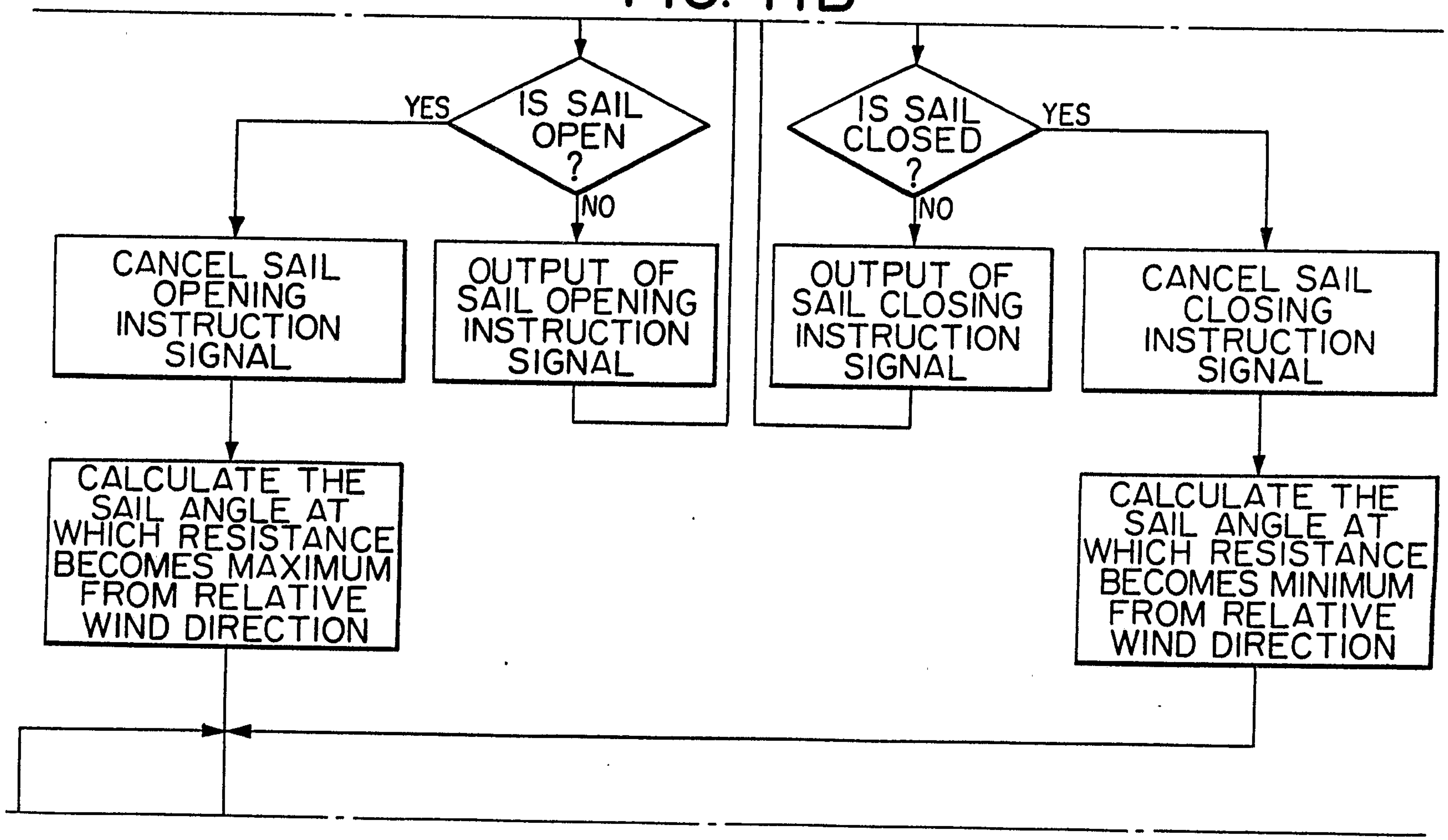

IS SAIL OPEN ?
YES
NO
CANCEL SAIL OPENING INSTRUCTION SIGNAL
OUTPUT OF SAIL OPENING INSTRUCTION SIGNAL
CALCULATE THE SAIL ANGLE AT WHICH RESISTANCE BECOMES MAXIMUM FROM RELATIVE WIND DIRECTION
IS SAIL CLOSED ?
YES
NO
OUTPUT OF SAIL CLOSING INSTRUCTION SIGNAL
CANCEL SAIL CLOSING INSTRUCTION SIGNAL
CALCULATE THE SAIL ANGLE AT WHICH RESISTANCE BECOMES MINIMUM FROM RELATIVE WIND DIRECTION

FIG. 11C

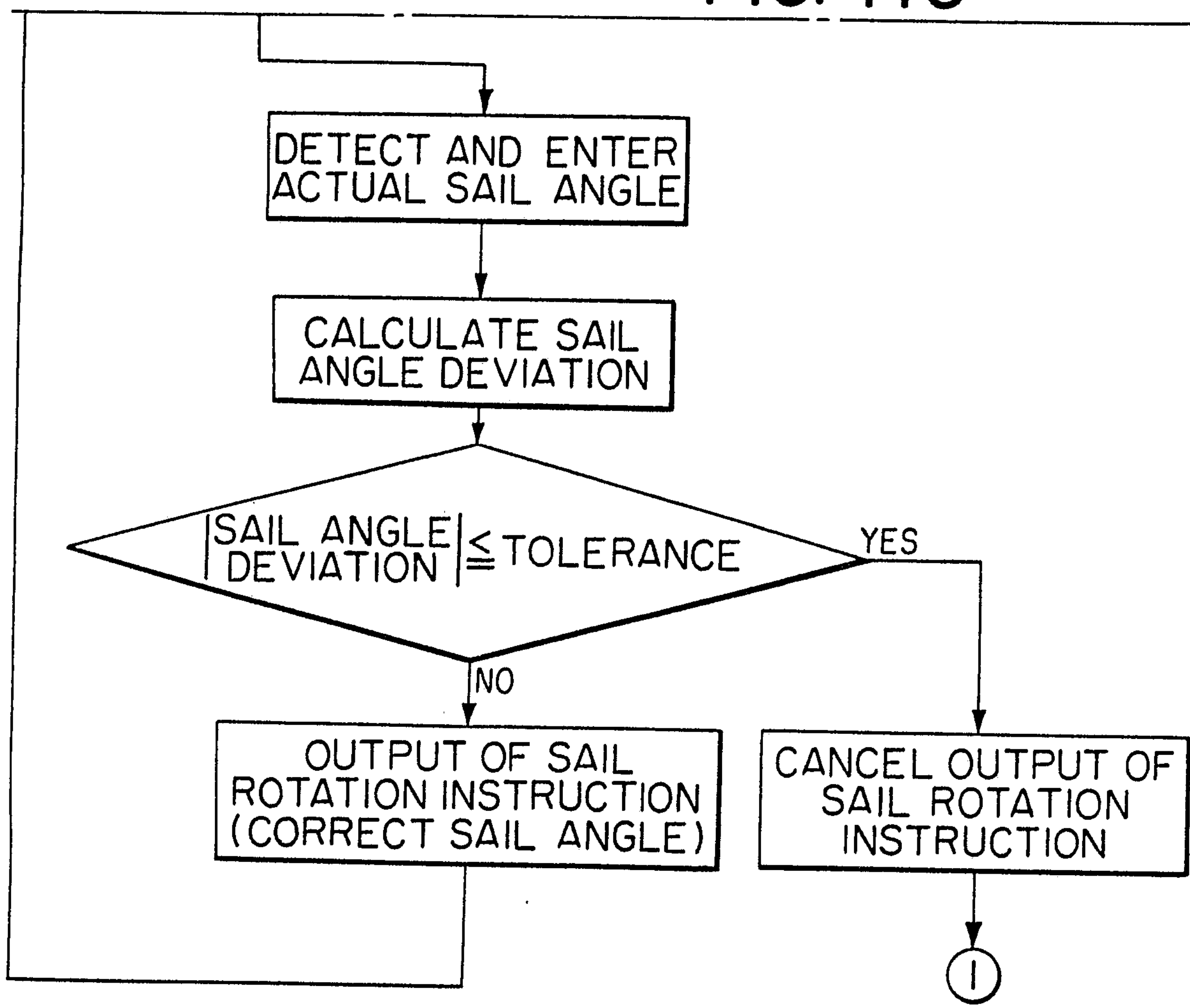
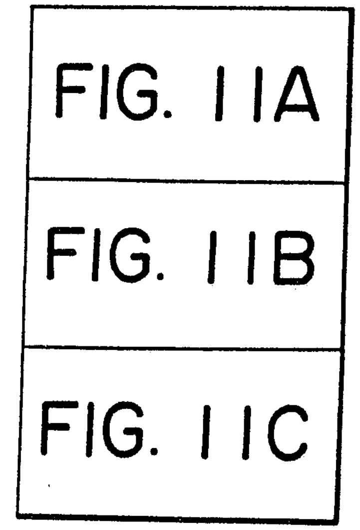


FIG. 11



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European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 81 30 3288

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
T	THE RADIO AND ELECTRONIC ENGINEER vol. 43, nr. 12, December 1973 London, GB J. ELLIOT: "The computation of the best windward and running courses for sailing yachts", pages 715-720 --	1,5	B 63 B 49/00 B 63 H 9/06 G 01 P 13/02
	FR - A - 2 167 324 (CARTIER) * Page 1, line 1 - page 2, line 10 * --	1	
	US - A - 3 935 828 (PFUND) * Column 1, line 1 - column 3, line 19 * --	1,5	TECHNICAL FIELDS SEARCHED (Int. Cl.3) B 63 B B 63 H B 63 G G 01 P
A	DE - B - 1 089 656 (PROLLS) * Column 5, line 35 - column 6, line 25 * --	1,5	
A	US - A - 3 934 533 (WAINWRIGHT) * Figures 4,5,11,15; column 1, lines 1-40 * --	5	CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
A	GB - A - 1 121 620 (SHERWOOD) * Page 1, lines 1-70 * ----	5	
	The present search report has been drawn up for all claims		&: member of the same patent family, corresponding document

Place of search	Date of completion of the search	Examiner
The Hague	21-10-1981	WASSENAAR

EPO Form 1503.1 06.78